a quantum-mechanical correction term occurs, give in our case

$$\cos\theta = c/(n_1\beta)\cdot(1+\kappa_0^2/(n_2^2\kappa^2))^{\frac{1}{2}} + \tfrac{1}{2}\Lambda\{\kappa(1-1/n_1^2)-\kappa_0^2/(n_1^2n_2^2\kappa)\},$$

where θ is the angle between the direction of the emitted meson and that of the incident nucleon before the emission of the meson and β is the v/c ratio of the nucleon before the emission. Λ is the de Broglie wave-length of the nucleon before the emission given by $\Lambda = \hbar(1-\beta^2)^{\frac{1}{2}}/Mv$.

The second term in the expression for $\cos\theta$ is obviously the quantum-mechanical correction term since it contains $\hbar$. If one lets the rest mass of the meson go to zero, one obtains Cox's formula in the electromagnetic Čerenkov radiation.

The first term in the present formula for $\cos\theta$ may be regarded as a classical term, for when replacing the square root by the phase velocity of the meson the classical formula for the sine of the Mach angle results. However, θ still depends upon κ, the momentum of the meson.

I wish to thank Dr. O. Laporte for advice and encouragement.

[1] R. T. Cox, Phys. Rev. 66, 106 (1944).

Nuclear Capture of L_I Electrons

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THE phenomenon of L-capture, the observation of which we reported a few months ago,[1] has been investigated in detail. Proportional counters filled with various gases and traces of A^{37} were used. The technique in measuring carefully the ratio of energies was described previously.[2] Two counter types and four fillings were used, as indicated in Table I. The highest gas multiplication factor used was about 2×10^5. The A^{37} K-capture disintegration provides[1] a peak at an energy equal to the K ionization potential of Cl, 2.8 kev. Nuclear capture of L electrons should result in the liberation in the counter of an energy equal to the L ionization potential, about 1/10 of the K ionization potential. We have in fact observed such a low energy peak at about 1/10 of the energy of the main peak, using counters *I* and *II* with "argon" fillings. However, quite apart from the nuclear capture of L electrons, there must be a low energy peak in addition to the 2.8-kev peak for the following reasons. K-capture in A^{37} results in the formation of a Cl atom with an ionized K shell. In most cases (about 90 percent)[3] the whole of the 2.8-kev K binding energy is dissipated in the counter as Auger electrons. However, in about 10 percent of the cases a $K\alpha$-x-ray photon is emitted with consequent ionization of the L_{II} or L_{III} shell. This $K\alpha$-quantum may escape from the counter, i.e., there is a small probability, dependent on the absorptive power of the counter gas, that only the L_{II} or L_{III} ionization potential of Cl (200 ev)[4] is released in the counter. Consequently, in experiments with "argon" fillings where the escape probability* ϵ for the $K\alpha$-quantum is high (see Table I), the presence of a low energy peak should not in itself be considered as a proof of L orbital electron capture. The proof arises, rather, from the fact that the intensity of the low energy peak is definitely greater than would be expected only on the basis of the escape of K-radiation. Moreover, there is a difference between the low energy peak due to K-escape and that due to L-capture. The escape peak involves the L_{II} or L_{III} shell (200 ev), but in the nuclear L-capture L_I electrons are expected to be involved (i.e., S electrons) with release of about 280 ev.[5] We cannot resolve two peaks at 200 and 280 ev because the statistical spread[2] is too great. We can, however, reduce the K quantum escape probability to a small value by adding xenon, and thus be left substantially with the effects of L-capture alone (see Table I). This was done with the "xenon" fillings.

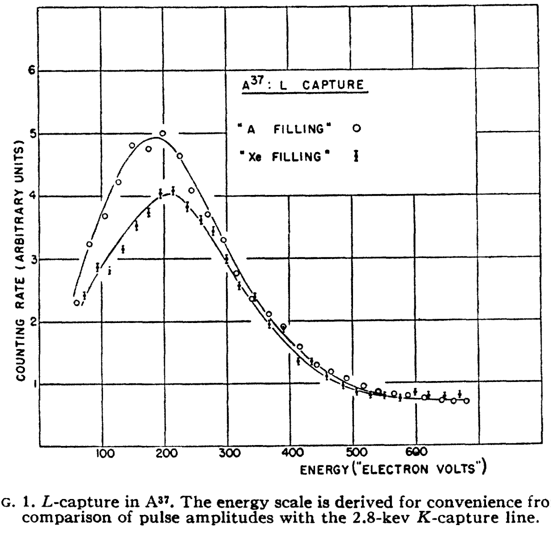

FIG. 1. L-capture in A^{37}. The energy scale is derived for convenience from a comparison of pulse amplitudes with the 2.8-kev K-capture line.

TABLE I. Counter types used.

	Counter *I*	Counter *II*
Active length (cm)	30	20
Internal diameter (cm)	2.35	4.65
"Argon" filling (cm Hg)	40 cm A 12 cm CH_4 $\epsilon=0.75$	41 cm A 11 cm CH_4 $\epsilon=0.66$
"Xenon" filling (cm Hg)	50 cm Xe 10 cm CH_4 $\epsilon=0.13$	26 cm Xe 14 cm A 10 cm CH_4 $\epsilon=0.15$

The curves in Fig. 1 have been normalized to refer to the same total disintegration rate of A^{37}. They show essentially L-capture with "xenon" filling, and L-capture$+K$-escape with "argon" filling. The two effects produced by Xe—decrease in intensity of the peak and the shifting of the peaks to higher energy—are apparent, and quantitatively they are in agreement with expectations within the experimental errors. Similar results were obtained with counter *I*.

The energy scale of Fig. 1 is obtained from the position of the 2.8-kev peak. It is noticed that the values for the L_I peak, as well as the value for the (L_I, L_{II}, L_{III}) peak, correspond to an energy smaller than the theoretical value. This is due in part to an increase in the mean energy necessary to produce an ion pair at low energy, and in part to a distortion of the shape due to an "end-effect tail."** The second difficulty enters also in estimating the ratio of the probabilities of L- and K-capture. A value of 8 to 9 percent is obtained for the L/K ratio with both Xe and A fillings when corrections for K-escape are made. The theoretical value is only 6 percent, according to Marshak,[6] but in view of the difficulties connected with the subtraction of background, we are not sure that the discrepancy is significant.

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[1] D. H. W. Kirkwood, B. Pontecorvo, and G. C. Hanna, Phys. Rev. **74**, 497 (1948).

[2] G. C. Hanna, D. H. W. Kirkwood, and B. Pontecorvo, Phys. Rev. **75**, 985 (1949).

[3] M. Haas, Ann. d. Physik **16**, 473 (1933); P. K. Weimer, J. D. Kurbatov, and M. L. Pool, Phys. Rev. **66**, 209 (1944).

[4] F. Holweck, *De la Lumière aux Rayons-X* (Paris, 1927).

* In evaluating ϵ, we have used as absorption coefficients of the Cl $K\alpha$-line: in A 260 cm²/g, in Xe 800 cm²/g, and in C 130 cm²/g.

[5] M. Siegbahn, *Spectroskopie der Röntgenstrahlen*, (Berlin, 1931).

** Counter *I*, having small end effect due to its high length to diameter ratio, gives energy values close to the expected one. Curves referring to Counter *I* are not shown here for lack of space, a pertinent curve having been shown in another letter (see reference 2).

[6] Robert E. Marshak, Phys. Rev. **61**, 431 (1942).